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Incorporating corrigenda December 2014 and December 2015



BSI Standards Publication

Information technology — Dynamic adaptive streaming over HTTP (DASH)

Part 1: Media presentation description and
segment formats

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National foreword

This British Standard is the UK implementation of ISO/IEC 23009-1:2014+A2:2015, incorporating corrigenda December 2014 and December 2015. It supersedes BS ISO/IEC 23009-1:2014, which is withdrawn.

Due to the technical nature of the amendments, ISO/IEC amendment 1:2015 and ISO/IEC amendment 2:2015 are appended at the end of this document.

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**Information technology — Dynamic
adaptive streaming over HTTP (DASH) —**

Part 1:

**Media presentation description and
segment formats**

*Technologies de l'information — Diffusion en flux adaptatif dynamique
sur HTTP (DASH) —*

*Partie 1: Description de la présentation et formats de remise des
médias*



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Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of the joint technical committee is to prepare International Standards. Draft International Standards adopted by the joint technical committee are circulated to national bodies for voting. Publication as an International Standard requires approval by at least 75 % of the national bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights.

ISO/IEC 23009-1 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

This second edition cancels and replaces the first edition (ISO/IEC 23009-1:2012), which has been technically revised. It also incorporates the Technical Corrigendum ISO/IEC 23009-1:2012/Cor.1:2013.

ISO/IEC 23009 consists of the following parts, under the general title *Information technology — Dynamic adaptive streaming over HTTP (DASH)*:

- *Part 1: Media presentation description and segment formats*
- *Part 2: Conformance and reference software*
- *Part 3: Implementation guidelines* [Technical Report]
- *Part 4: Segment encryption and authentication*

Introduction

Dynamic Adaptive Streaming over HTTP (DASH) is intended to support a media-streaming model for delivery of media content in which control lies exclusively with the client. Clients may request data using the HTTP protocol from standard web servers that have no DASH-specific capabilities. Consequently, this part of ISO/IEC 23009 focuses not on client or server procedures but on the data formats used to provide a DASH Media Presentation.

This part of ISO/IEC 23009 primarily specifies formats for the Media Presentation Description and Segments. It is applicable to streaming services over the Internet.

Information technology — Dynamic adaptive streaming over HTTP (DASH) —

Part 1: Media presentation description and segment formats

1 Scope

This part of ISO/IEC 23009 primarily specifies formats for the Media Presentation Description and Segments for dynamic adaptive streaming delivery of MPEG media over HTTP. It is applicable to streaming services over the Internet.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ITU-T Rec. H.222.0 | ISO/IEC 13818-1, *Information technology — Generic coding of moving pictures and associated audio information: Systems*

ISO/IEC 14496-10, *Information technology — Coding of audio-visual objects — Part 10: Advanced Video Coding*

ISO/IEC 14496-12, *Information technology — Coding of audio-visual objects — Part 12: ISO base media file format* (technically identical to ISO/IEC 15444-12)

ISO/IEC 23001-8, *Information technology — MPEG systems technologies — Part 8: Coding-independent code points*

IETF RFC 2141, *URN Syntax*, May 1997

IETF RFC 2616, *Hypertext Transfer Protocol – HTTP/1.1*, June 1999

IETF RFC 3023, *XML Media Types*, January 2001

IETF RFC 3406, *Uniform Resource Names (URN) Namespace Definition Mechanisms*, October 2002

IETF RFC 3629, *UTF-8, a transformation format of ISO 10646*, November 2003

IETF RFC 3986, *Uniform Resource Identifier (URI): Generic Syntax*, January 2005

IETF RFC 4122, *A Universally Unique Identifier (UUID) URN Namespace*, July 2005

IETF RFC 4288, *Media Type Specifications and Registration Procedures*, December 2005

IETF RFC 4337, *MIME Type Registration for MPEG-4*, March 2006

IETF RFC 4648, *The Base16, Base32, and Base64 Data Encodings*, October 2006

IETF RFC 5261, *An Extensible Markup Language (XML) Patch Operations Framework Utilizing XML Path Language (XPath) Selectors*, September 2008

IETF RFC 5646, *Tags for Identifying Languages*, September 2009

IETF RFC 6265, *HTTP State Management Mechanism*, April 2011

IETF RFC 6381, *The 'Codecs' and 'Profiles' Parameters for "Bucket" Media Types*, August 2011

W3C XLINK *XML Linking Language (XLink) Version 1.1*, W3C Recommendation 06, May 2010

W3C Media Fragments URI 1.0 (basic), W3C Recommendation, 25 September 2012

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

access unit

unit of a media stream with an assigned Media Presentation time

3.1.2

accessibility

degree to which a media content or certain media content components are available to as many people as possible

3.1.3

Adaptation Set

set of interchangeable encoded versions of one or several media content components

3.1.4

asset

content including media and metadata together with the rights to use the content by the content provider

3.1.5

available Segment

Segment that is accessible at its assigned HTTP-URL and a possibly assigned byte range that is the request with an HTTP GET results in a reply of the Segment and 2xx status code

3.1.6

Bitstream Switching Segment

Segment that if present contains essential data to switch to the Representation it is assigned to

3.1.7

complementary Representation

Representation which complements at least one dependent Representation

3.1.8

continuous media

media with an inherent notion of time, for example, speech, audio, video, timed text or timed metadata

3.1.9

DASH metric

metric identified by a key and defined in this part of ISO/IEC 23009

3.1.10

dependent Representation

Representation for which Segments from its complementary Representations are necessary for presentation and/or decoding of the contained media content components

3.1.11

earliest presentation time

smallest presentation time of any access unit of a Media Segment or Subsegment for a media stream

3.1.12

event

aperiodic sparse media-time related auxiliary information to the DASH client or to an application

3.1.13

event stream

sequence of related events

3.1.14

group

collection of Adaptation Sets that are not expected to be presented simultaneously

3.1.15

HTTP-URL

URL with a fixed scheme of “http” or “https”

3.1.16

Index Segment

Segment that primarily contains indexing information for Media Segments

3.1.17

Initialization Segment

Segment containing metadata that is necessary to present the media streams encapsulated in Media Segments

3.1.18

media content

one media content period or a contiguous sequence of media content periods

3.1.19

media content component

one continuous component of the media content with an assigned media component type that can be encoded individually into a media stream

3.1.20

media content component type

single type of media content such as audio, video, or text

3.1.21

media content period

set of media content components that have a common timeline as well as relationships on how they can be presented

3.1.22

Media Presentation

collection of data that establishes a bounded or unbounded presentation of media content

3.1.23

Media Presentation Description

MPD

formalized description for a Media Presentation for the purpose of providing a streaming service

3.1.24

Media Presentation timeline

concatenation of the timeline of all Periods which itself is common to all Representations in the Period

3.1.25

Media Segment

Segment that complies with media format in use and enables playback when combined with zero or more preceding segments, and an Initialization Segment (if any)

3.1.26

media stream

encoded version of a media content component

3.1.27

Media Subsegment

Subsegment that only contains media data but no Segment Index

3.1.28

message

part of an event containing information that is exclusively handled by the event handler

3.1.29

MPD start time

approximate presentation start time of a Media Segment signalled in MPD

3.1.30

MPD duration

approximate presentation duration of a Media Segment signalled in MPD

3.1.31

Period

interval of the Media Presentation, where a contiguous sequence of all Periods constitutes the Media Presentation

3.1.32

presentation time

time associated to an access unit that maps it to the Media Presentation timeline

3.1.33

remote element entity

entity that contains one or more elements and is referenced in the MPD with an HTTP-URL contained in an `@xlink:href` attribute

3.1.34

Representation

collection and encapsulation of one or more media streams in a delivery format and associated with descriptive metadata

3.1.35

Segment

unit of data associated with an HTTP-URL and optionally a byte range that are specified by an MPD

3.1.36

Segment availability start time

latest time instant in wall-clock time at which a Segment becomes an available Segment

3.1.37

adjusted Segment availability start time

time instant in wall-clock time at which a Segment becomes an available Segment

3.1.38

Segment availability end time

time instant in wall-clock time at which a Segment ceases to be an available Segment

3.1.39

Segment Index

compact index of the time range to byte range mapping within a Media Segment separately from the MPD

3.1.40

stream access point

SAP

position in a Representation enabling playback of a media stream to be started using only the information contained in Representation data starting from that position onwards (preceded by initializing data in the Initialization Segment, if any)

3.1.41

Sub-Representation

part of a Representation described in the MPD that is present in the entire Period

3.1.42

Subsegment

unit within Media Segments that is indexed by a Segment Index

3.1.43

valid Segment URL

HTTP-URL that is promised to reference a Segment during its Segment availability period

3.1.44

wall-clock time

time as stated by UTC

3.2 Symbols and abbreviated terms

For the purposes of this document, the following symbols and abbreviated terms apply.

AVC	advanced video coding
CAT	conditional access table
DASH	dynamic adaptive streaming over HTTP
DM	DASH Metrics
DRM	digital rights management
ECM	entitlement control message
HTTP	hypertext transfer protocol
IDR	instantaneous decoding refresh

ISOBMFF	ISO base media file format
MPD	Media Presentation Description
MVC	multi-view video coding
PAT	program association table
PCR	program clock reference
PES	packetized elementary stream
PID	packet identifier
PMT	program map table
PSI	program specific information
PTS	presentation time stamp
SAP	stream access point
SEI	supplementary enhancement information
SVC	scalable video coding
TCP	transmission control protocol
TLS	transport layer security
TS	transport stream
URI	uniform resource identifier
URL	uniform resource locator
URN	uniform resource name
UTC	coordinated universal time
UUID	universally unique identifier
XML	extensible mark-up language

3.3 Conventions

The following naming conventions apply in this document.

- Elements in an XML document are identified by an upper-case first letter and in bold face as **Element**. To express that an element **Element1** is contained in another element **Element2**, we may write **Element2.Element1**. If an element's name consists of two or more combined words, camel-casing is typically used, e.g. **ImportantElement**. Elements may be present either exactly once, or the minimum and maximum occurrence is defined by <minOccurs> ... <maxOccurs>.
- Attributes in an XML document are identified by a lower-case first letter as well as they are preceded by a '@'-sign, e.g. @attribute. To point to a specific attribute @attribute contained in an element **Element**, one may write **Element@attribute**. If an attribute's name consists of two or more combined words, camel-casing is typically used after the first word, e.g.

@veryImportantAttribute. Attributes may have assigned a status in the XML as mandatory (M), optional (O), optional with default value (OD) and conditionally mandatory (CM).

- Namespace qualification of elements and attributes is used as per XML standards, in the form of **namespace:Element** or @namespace:attribute. The fully qualified namespace will be provided in the schema fragment associated with the declaration. External specifications extending the namespace of DASH are expected to document the element name in the semantic table with an extension namespace prefix.
- Variables defined in the context of this document are specifically highlighted with *italics*, e.g. *InternalVariable*.
- Structures that are defined as part of the hierarchical data model are identified by an upper-case first letter, e.g. Period, Adaptation Set, Representation, Segment, etc.
- The term "this clause" refers to the entire clause included within the same first heading number. The term "this subclause" refers to all text contained in the subclause with the lowest hierarchy heading.

4 Introduction

4.1 System description

Dynamic Adaptive Streaming over HTTP (DASH) specifies XML and binary formats that enable delivery of media content from standard HTTP servers to HTTP clients and enable caching of content by standard HTTP caches.

This part of ISO/IEC 23009 primarily defines two formats:

- The Media Presentation Description (MPD) describes a *Media Presentation*, i.e. a bounded or unbounded presentation of media content. In particular, it defines formats to announce resource identifiers for *Segments* and to provide the context for these identified resources within a Media Presentation. These resource identifiers are HTTP-URLs possibly combined with a byte range.
- The Segment formats specify the formats of the entity body of the HTTP response to an HTTP GET request or a partial HTTP GET with the indicated byte range using HTTP/1.1 as defined in RFC 2616 to a resource identified in the MPD. Segments typically contain efficiently coded media data and metadata conforming to or at least closely aligned with common media formats.

The MPD provides sufficient information for a client to provide a streaming service to the user by accessing the Segments through the protocol specified in the scheme of the defined resources. In the context of this part of ISO/IEC 23009 the assumed protocol is HTTP/1.1. Such a client is referred to as a DASH Client in the remainder of 23009-1. However, this part of ISO/IEC 23009 does not provide a normative specification for such a client.

Figure 1 shows a possible deployment architecture in which the formats defined in this part of ISO/IEC 23009 may be used. Boxes with solid lines indicate devices that are mentioned in this specification as they host or process the formats defined in this specification whereas dashed boxes are conceptual or transparent. This part of ISO/IEC 23009 deals with the definition of formats that are accessible on the interface to the DASH Client, indicated by the solid lines. Any other formats or interfaces are not in scope of this Part of ISO/IEC 23009. In the considered deployment scenario, it is assumed that the DASH Client has access to an MPD. The MPD provides sufficient information for the DASH Client to provide a streaming service to the user by requesting Segments from an HTTP server and demultiplexing, decoding and rendering the included media streams.

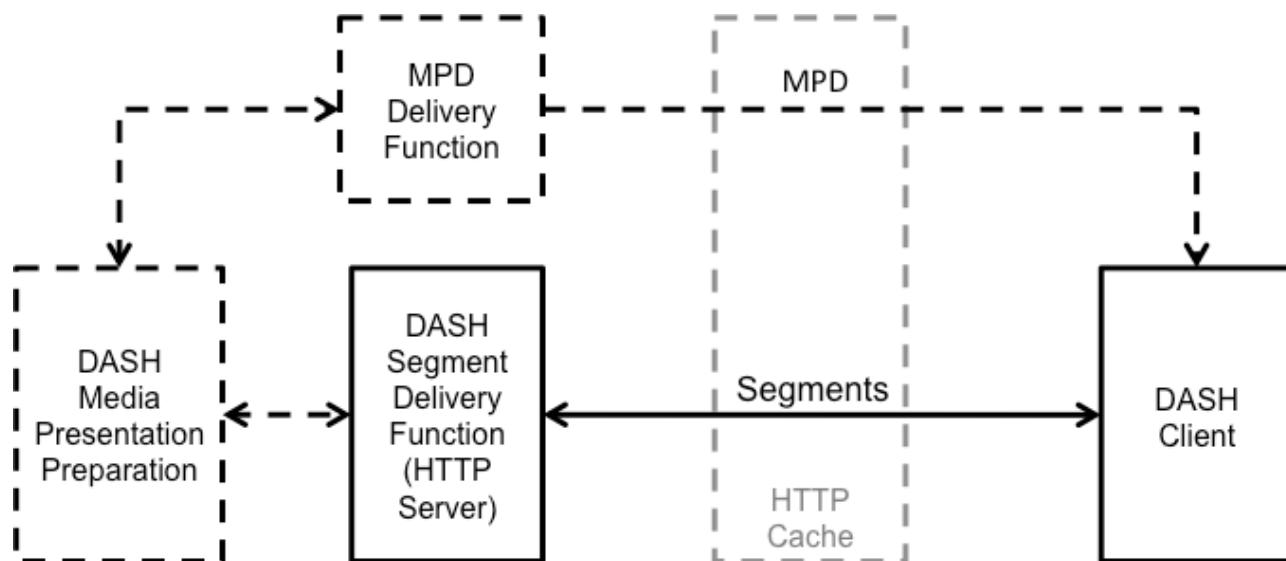


Figure 1 — Example system for DASH formats

Note that despite the formats are initially designed to be used in the above deployment scenario their application is obviously not restricted to this scenario. The particular aspect on "HTTP" in DASH is the usage of HTTP-URLs in the MPD for the purpose to refer to Segments. The usage of HTTP-URLs enables unique location information and it provides well-defined methods to access the resources, in particular HTTP GET and HTTP partial GET.

4.2 DASH client model

The design of the formats defined in this part of ISO/IEC 23009 is based on the informative client model as shown in Figure 2. The figure illustrates the logical components of a conceptual DASH client model. In this figure the DASH access engine receives the Media Presentation Description (MPD), constructs and issues requests and receives Segments or parts of Segments. In the context of this part of ISO/IEC 23009, the output of the DASH access engine consists of media in MPEG container formats (ISO/IEC 14496-12 ISO Base Media File Format or ISO/IEC 13818-1 MPEG-2 Transport Stream), or parts thereof, together with timing information that maps the internal timing of the media to the timeline of the Media Presentation. In Annex F of this part of ISO/IEC 23009, guidance on enabling the use of this part of ISO/IEC 23009 with other container formats is provided. In addition, the DASH access client may also receive and extract Events that are related to the media time. The events may be processed in the DASH client or may be forwarded to an application in the execution environment of the DASH client.

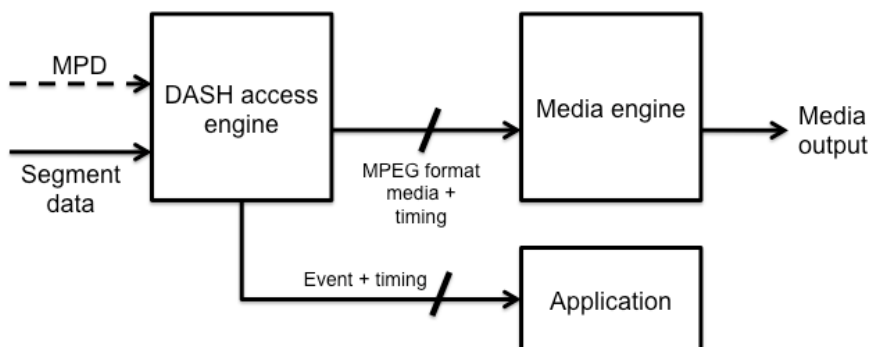


Figure 2 — DASH Client Model

4.3 DASH data model overview

DASH is intended to support a media-streaming model for delivery of media content in which control lies primarily with the client. Clients may request data using the HTTP protocol from standard web servers that have no DASH-specific capabilities. Consequently, this standard focuses not on client or server procedures but on the data formats used to provide a DASH Media Presentation.

The collection of encoded and deliverable versions of media content and the appropriate description of these form a Media Presentation. Media content is composed of a single or multiple contiguous media content **periods** in time. Content in different media content periods may be completely independent or certain periods of a Media Presentation may belong to the same Asset, for example a Media Presentation is a collection of main program composed of multiple periods, each assigned to the same Asset, and interleaved with inserted advertisement periods. Each media content period is composed of one or multiple **media content components**, for example audio components in various languages, different video components providing different views of the same program, subtitles in different language, etc.. Each media content component has an assigned **media content component type**, for example audio or video.

Each media content component may have several encoded versions, referred to as **media streams**. Each media stream inherits the properties of the media content, the media content period, the media content component from which it was encoded and in addition it gets assigned the properties of the encoding process such as sub-sampling, codec parameters, encoding bitrate, etc. This describing metadata is relevant for static and dynamic selection of media content components and media streams.

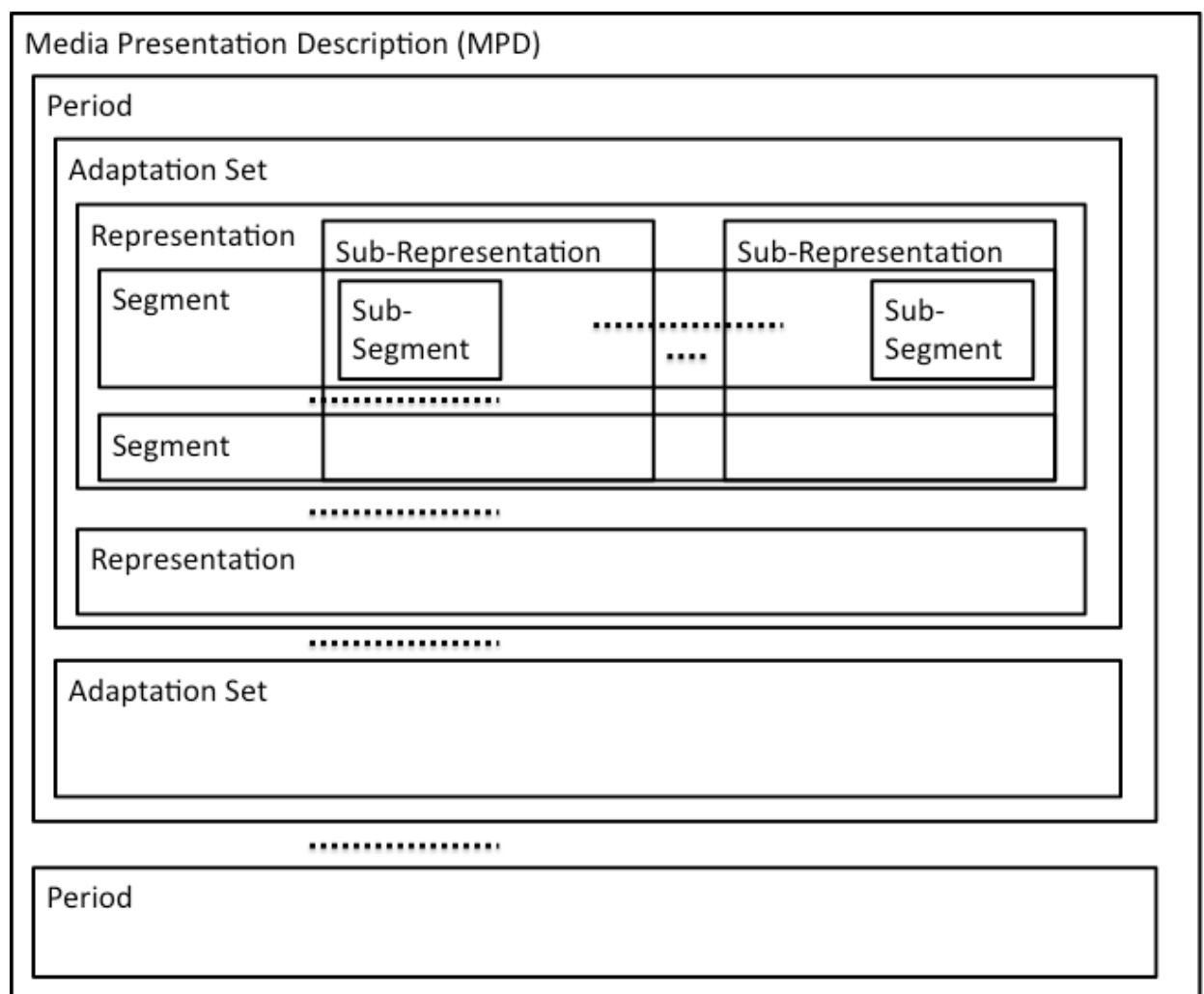


Figure 3 — DASH High-Level Data Model

DASH is based on a hierarchical data model aligned with the presentation in Figure 3. A DASH Media Presentation is described by a **Media Presentation Description** document. This describes the sequence of **Periods** (see 5.3.2) in time that make up the Media Presentation. A Period typically represents a media content period during which a consistent set of encoded versions of the media content is available i.e. the set of available bitrates, languages, captions, subtitles etc. does not change during a Period.

Within a Period, material is arranged into **Adaptation Sets** (see 5.3.3). An Adaptation Set represents a set of interchangeable encoded versions of one or several media content components (see 5.3.4). For example there may be one Adaptation Set for the main video component and a separate one for the main audio component. If there is other material available, for example captions or audio descriptions, then these may each have a separate Adaptation Set. Material may also be provided in multiplexed form, in which case interchangeable versions of the *multiplex* may be described as a single Adaptation Set, for example an Adaptation Set containing both the main audio and main video for a Period. Each of the multiplexed components may be described individually by a media content component description.

An Adaptation Set contains a set of **Representations** (see 5.3.5). A Representation describes a *deliverable encoded version* of one or several media content components. A Representation includes one or more media streams (one for each media content component in the multiplex). Any single Representation within an Adaptation Set is sufficient to render the contained media content components. By collecting different Representations in *one* Adaptation Set, the Media Presentation author expresses that the Representations represent perceptually equivalent content. Typically this means, that clients may switch dynamically from Representation to Representation within an Adaptation Set in order to adapt to network conditions or other factors. Switching refers to the presentation of decoded data up to a certain time *t*, and presentation of decoded data of another Representation from time *t* onwards. If Representations are included in one Adaptation Set, and the client switches properly, the Media Presentation is expected to be perceived seamless across the switch. Clients may ignore Representations that rely on codecs or other rendering technologies they do not support or that are otherwise unsuitable.

Within a Representation, the content may be divided in time into **Segments** (see 5.3.9 and 6) for proper accessibility and delivery. In order to access a Segment, a URL is provided for each Segment. Consequently, a Segment is the largest unit of data that can be retrieved with a single HTTP request.

NOTE This is not strictly true, since the MPD may also include a byte range with the URL, meaning that the Segment is contained in the provided byte range of some larger resource. An intelligent client could in principle construct a single request for multiple Segments, but this would not be the typical case.

DASH defines different timelines. One of the key features in DASH is that encoded versions of different media content components share a common timeline. The presentation time of each access unit within the media content is mapped to the global common presentation timeline for synchronization of different media components and to enable seamless switching of different coded versions of the same media components. This timeline is referred as Media Presentation timeline. The Media Segments themselves contain accurate Media Presentation timing information enabling synchronization of components and seamless switching.

A second timeline is used to signal to clients the availability time of Segments at the specified HTTP-URLs. These times are referred to as **Segment availability times** and are provided in wall-clock time. Clients typically compare the wall-clock time to Segment availability times before accessing the Segments at the specified HTTP-URLs in order to avoid erroneous HTTP request responses. For static Media Presentations, the availability times of all Segments are identical. For dynamic Media Presentations, the availability times of segments depend on the position of the Segment in the Media Presentation timeline, i.e. the Segments get available over time. Whereas static Media Presentations are suitable to offer On-Demand content, dynamic Media Presentations are mostly suitable to offer live services.

Segments are assigned a duration, which is the duration of the media contained in the Segment when presented at normal speed. Typically all Segments in a Representation have the same or roughly similar duration. However Segment duration may differ from Representation to Representation. A DASH presentation can be constructed with relative short segments (for example a few seconds), or longer Segments including a single Segment for the whole Representation.

Short Segments are usually required in the case of live content, where there are restrictions on end-to-end latency. The duration of a Segment is typically a lower bound on the end-to-end latency. DASH does not

support the possibility for Segments to be extended over time: a Segment is treated as an object as a complete and discrete unit that must be made available in its entirety. However, this does not prevent to apply advanced HTTP transfer modes such as chunked transfer to optimize deployments and reduce end-to-end latency.

Segments may be further subdivided into **Subsegments** each of which contains a whole number of complete access units. There may also be media-format-specific restrictions on Subsegment boundaries, for example in the ISO Base Media File Format a Subsegment must contain a whole number of complete movie fragments. If a Segment is divided into Subsegments they are described by a compact **Segment index**, which provides the presentation time range in the Representation and corresponding byte range in the Segment occupied by each Subsegment. Clients may download this index in advance and then issue requests for individual Subsegments.

Clients may switch from Representation to Representation within an Adaptation Set at any point in the media. However, switching at arbitrary positions may be complex because of coding dependencies within Representations and other factors, potentially requiring parallel download and decoding in the DASH client. It is also desirable to avoid download of 'overlapping' data i.e. media for the same time period from multiple Representations. Usually, switching is simplest at a Stream Access Point (SAP) in the new stream. In order to formalize requirements related to switching DASH defines a codec-independent concept of Stream Access Points and identifies various types of Stream Access Points.

Segmentation and Subsegmentation may be performed in ways that make switching simpler. For example, in the very simplest cases each Segment or Subsegment begins with a SAP and the boundaries of Segments or Subsegments are aligned across the Representations of one Adaptation Set. In this case, switching Representation involves playing to the end of a (Sub)Segment of one Representation and then playing from the beginning of the next (Sub)Segment of the new Representation. The Media Presentation Description and Segment Index provide various indications, which describe properties of the Representations that may make switching simpler. Profiles of this specification may then require these indicators to be set in certain ways, making implementation of clients for those profiles simpler at the cost of requiring the media data to obey the indicated constraints.

For On-Demand services, the Media Presentation Description is typically a static document describing the various aspects of the Media Presentation. All Segments of the Media Presentation are available on the server once any Segment is available. For live services, however, Segments become available with time as the content is produced and therefore, dynamic Media Presentations are suitable. The Media Presentation Description may be updated regularly to reflect changes in the presentation over time, for example Segment URLs for new segments may be added to the MPD and those for old, no longer available Segments may be removed. However, if Segment URLs are described using a template, this updating may not be necessary except for some redundancy/failover cases.

Events may be provided in the MPD or within a Representation in order to signal aperiodic information to the DASH client or to an application. Events are timed, i.e. each event starts at a specific media presentation time and typically has duration. Events include DASH specific signalling or application-specific events. Examples for events are indication of MPD updates on the server, possibly providing the detailed update as part of the messages. The event mechanisms may also be used to deliver media time related application events, for example information about ad insertion opportunities, etc.

4.4 Protocols

This Part of ISO/IEC 23009 may be deployed in a system according to Figure 1 for which

- The DASH Client includes a *client* as specified in RFC 2616 and,
- The HTTP Server hosting the DASH Segments complies with a *server* as specified in RFC 2616.

DASH Clients typically use the HTTP GET method or the HTTP partial GET method, as specified in RFC 2616, Clause 9.3, to access Segments or parts thereof.

The use of HTTP as a transport protocol inherently provides many advanced features such as caching, redirection or authentication. As another example, transport security in HTTP-based delivery may be achieved by using HTTP over TLS as specified in RFC 2818. Yet another example is the use of HTTP state management mechanisms (also known as Cookies) as defined in RFC 6265.

However, the formats defined in this part of ISO/IEC 23009 may also be used with other protocols. In particular, the objects may be delivered with any object delivery protocol that provides a binding between an HTTP-URL and the delivered object.

4.5 Media Stream and Representation properties

4.5.1 Switching and Random Access Support

AC1 The formats defined in this part of the standard are designed for providing good user experience even in case the access bandwidth between the DASH segment delivery function or the cache varies. A key functionality is the ability that the DASH client can seamlessly switch across different Representations of the same media component without severely impacting the user experience.

Assume two Representations A and B. A switch from Representations A to Representation B at media time t is considered seamless, if the result of the presentation after this switch is applied is identical as if Representation A is decoded from the beginning and presented up to time t and Representation B is decoded from the beginning and presented from time t onwards.

Media Presentations may provide different Representations in one Adaptation Set representing the same media component. If such Representations are properly time-aligned (as expected by the Media Presentation), then DASH clients may apply seamless switching across different Representations provided in one Adaptation Set at any time t to obtain a perceptually continuous experience.

However, in practical implementations, the operation of seamless switching may be complex, as switching at time t may require parallel download and decoding of two Representations. Therefore, providing suitable switching opportunities in regular time intervals simplifies client implementations. This part of ISO/IEC 23009-1 provides means for providing suitable switching opportunities and in addition provides abilities to signal the position and media time of the switching opportunities.

For this purpose this subsection defines three relevant concepts to support seamless switching:

- Media stream access points in 4.5.2 to signal positions where to easily switch to a Representation, and in addition where to suitable access a Representation at start-up or seek.
- Non-overlapping Segments and Subsegments in 4.5.3 to signal that at the signalled stream access points, no overlap decoding of Representations is necessary in order to provide a continuous switch.
- Bitstream concatenation in 4.5.4 to signal that the concatenation of two Representations at a switch point results in a conforming bitstream.

These three properties are neither sufficient nor necessary for seamless switching, but certain implementation or profiles may use these properties in order to simplify practical implementations. **AC1**

4.5.2 Media stream access points

To be able to access a Representation, each of the media streams that are contained in the Representation requires Media Stream Access Points (SAPs). SAPs in the context of this part of ISO/IEC 23009 refer to the SAP definition in ISO/IEC 14496-12 Annex I. ISO/IEC 14496-12 Annex I.3 defines different types of SAPs that provide a relationship between the position where a stream can be accessed, relative to the start of a Segment or Subsegment, its presentation time and the presentation times and position of other access unit in the stream. The same SAP type definitions shall apply for this part of ISO/IEC 23009.

A SAP is a position in a Representation that enables playback of a media stream to be started using only the information contained in Representation data starting from that position onwards (preceded by initializing data in the Initialization Segment, if any).

For each SAP the properties, I_{SAP} , T_{SAP} , I_{SAU} , T_{DEC} , T_{EPT} , and T_{PTF} are identified and defined in ISO/IEC 14496-12 Annex I.2.

In particular, T_{SAP} is defined to be earliest presentation time of any access unit of the media stream such that all access units of the media stream with presentation time greater than or equal to T_{SAP} can be correctly decoded using data in the Representation starting at byte position I_{SAP} and no data before I_{SAP} .

NOTE The type of SAP is dependent only on which Access Units are correctly decodable and their arrangement in presentation order. The types informally correspond with some common terms:

- Type 1 corresponds to what is known in some coding schemes as a “Closed GoP random access point” (in which all access units, in decoding order, starting from I_{SAP} can be correctly decoded, resulting in a continuous time sequence of correctly decoded access units with no gaps) and in addition the access unit in decoding order is also the first access unit in presentation order.
- Type 2 corresponds to what is known in some coding schemes as a “Closed GoP random access point”, for which the first access unit in decoding order in the media stream starting from I_{SAU} is not the first access unit in presentation order.
- Type 3 corresponds to what is known in some coding schemes as an “Open GoP random access point”, in which there are some access units in decoding order following I_{SAU} that cannot be correctly decoded and have presentation times less than T_{SAP} .
- Type 4 corresponds to what is known in some coding schemes as an “Gradual Decoding Refresh (GDR) random access point”, in which there are some access units in decoding order starting from and following I_{SAU} that cannot be correctly decoded and have presentation times less than T_{SAP} .
- Type 5 corresponds to the case for which there is at least one access unit in decoding order starting from I_{SAP} that cannot be correctly decoded and has presentation time greater than T_{DEC} and where T_{DEC} is the earliest presentation time of any access unit starting from I_{SAU} .
- Type 6 corresponds to the case for which there is at least one access unit in decoding order starting from I_{SAP} that cannot be correctly decoded and has presentation time greater than T_{DEC} and where T_{DEC} is not the earliest presentation time of any access unit starting from I_{SAU} .

SAPs are mostly relevant for two purposes in this part of ISO/IEC 23009:

1. For randomly accessing a Media Presentation, for example at the startup of the Media Presentation, after a seeking operation or after an error event especially in live cases.
2. To permit switching between two Representations whereby for seamless switching each media stream i in the switch-from Representation is presented up to $T_{SAP}(i)$ and each media stream i in the switch-to Representation is presented from the media Stream Access Point starting from $T_{SAP}(i)$.

There are obvious benefits for the client to be able to identify SAPs and one or several of their properties, in particular I_{SAP} and T_{SAP} for each media stream without requiring to access data at positions following I_{SAP} . DASH provides functionalities to explicitly signal such information by using signals in the MPD or the Segment Index or combinations of the two.

4.5.3 Non-overlapping Segments and Subsegments

Segments and Subsegments represent units for which the client has an exact map on how to access and download the unit using HTTP GET or HTTP partial GET methods.

Segments (respectively Subsegments) are typically generated by segmenting encoded media streams into appropriate units. If the generation of Segments (respectively Subsegments) adheres to certain rules, then the sequential decoding and presentation of Media Segments (respectively Subsegments) results in a correct presentation of all contained media streams. To define such rules the notion of “non-overlapping” segments (respectively Subsegments) is defined as follows.

Let

- $T_E(S,i)$ be the earliest presentation time of any access unit in stream i of a Segment or Subsegment S ,
- $T_L(S,i)$ be the latest presentation time of any access unit in stream i of a Segment or Subsegment S .

Then two segments (respectively Subsegments), A and B , which may or may not be of different Representations, are *non-overlapping* if $T_L(A,i) < T_E(B,i)$ for all media streams i in A and B or if $T_L(B,i) < T_E(A,i)$ for all streams i in A and B where i refers to the same media component.

The property of “non-overlapping” segments (respectively Subsegments) is used to define the terms Segment alignment and Subsegment alignment.

4.5.4 Bitstream concatenation

A sequence of Segments (respectively Subsegments) is a “conforming Segment (respectively Subsegment) sequence” if the concatenation of all Segments (respectively Subsegments) in the sequence of Segments (respectively Subsegments) results in a bitstream that conforms to the media formats in use (including container and codecs).

NOTE This implies that a player conforming to the media format can play the resulting bitstream.

4.6 Brands

The ISO Base Media File Format, ISO/IEC 14496-12, defines the concept of brands; brand values identify specifications or conformance points. This part of ISO/IEC 23009 specifies several brands, as listed in Table 1.

Table 1 — Brands defined in this part of ISO/IEC 23009

Brand Identifier	Clause in this part of ISO/IEC 23009	Informative description
emsg	5.10.3.3	Event message box
msdh	6.3.4.2	Media Segment conforming to the general format type for ISO base media file format.
msix	6.3.4.3	Media Segment conforming to the Indexed Media Segment format type for ISO base media file format.
sims	6.3.4.4	Media Segment conforming to the Sub-Indexed Media Segment format type for ISO base media file format.
dsms	6.3.5.1	Media Segment conforming to the DASH Self-Initializing Media Segment format type for ISO base media file format.
dash	6.3.5.2	ISO base media file format file specifically designed for DASH including movie fragments and Segment Index.
sisx	6.4.6.2	Single Index Segment used to index MPEG-2 TS based Media Segments.
risx	6.4.6.3	Representation Index Segment used to index MPEG-2 TS based Media Segments.
ssss	6.4.6.4	Subsegment Index Segment used to index MPEG-2 TS based Media Segments.
lmsg	7.3.1	last Media Segment indicator for ISO base media file format.

4.7 Schemes

This part of ISO/IEC 23009 specifies several schemes as listed in Table 2.

Table 2 — Schemes defined in this part of ISO/IEC 23009

Scheme Identifier	Clause in this part of ISO/IEC 23009	Informative description
urn:mpeg:dash:schema:mpd:2011	Annex B	The namespace of the XML schema for the MPD.
urn:mpeg:dash:resolve-to-zero:2013	5.5.3	xlink resolution to zero element
urn:mpeg:dash:mp4protection:2011	5.8.5.2	protection schemes identified by a the Scheme Type within the Scheme Type Box of the Protection Scheme Information Box of ISO/IEC14496-12.
urn:mpeg:dash:13818:1:CA_descriptor:2011	5.8.5.2	Conditional Access System used for ISO/IEC 13818-1 (MPEG-2 Transport Stream).
urn:mpeg:dash:14496:10:frame_packing_arrangement_type:2011	5.8.5.3	frame-packing arrangement.
urn:mpeg:dash:13818:1:stereo_video_format_type:2011	5.8.5.3	frame-packing arrangement.
AC1 urn:mpeg:dash:23003:3:audio_channel_configuration:2011	5.8.5.4	channel configuration. NOTE: legacy format for backward-compatibility, it is recommended to use the signaling as defined in ISO/IEC 23001-8 instead.
urn:mpeg:dash:outputChannelPositionList:2012	5.8.5.4	a list of output channel position to signal individual speaker positions as defined in ISO/IEC 23001-8. NOTE: legacy format for backward-compatibility, it is recommended to use the signalling as defined in ISO/IEC 23001-8 instead.
urn:mpeg:dash:role:2011	5.8.5.5	DASH role scheme.
urn:mpeg:dash:stereoid:2011	5.8.5.6	scheme for multiple views media content description.
urn:mpeg:dash:event:2012	5.10.4	DASH event signalling scheme
urn:mpeg:dash:profile:full:2011	8.2	identifier for Full profile.
urn:mpeg:dash:profile:isoff-on-demand:2011	8.3	identifier for ISO Base media file format On Demand profile.
urn:mpeg:dash:profile:isoff-live:2011	8.4	identifier for ISO Base media file format live profile.
urn:mpeg:dash:profile:isoff-main:2011	8.5	identifier for ISO Base media file format main profile.
urn:mpeg:dash:profile:mp2t-main:2011	8.6	identifier for MPEG-2 TS main profile.
urn:mpeg:dash:profile:mp2t-simple:2011	8.7	identifier for MPEG-2 TS simple profile.

5 Media Presentation

5.1 General

A Media Presentation is a collection of data that is accessible to a DASH Client to provide a streaming service to the user.

A Media Presentation is described by an MPD including possible updates of the MPD. The MPD is defined in 5.2 and the MPD update mechanism is defined in 5.4. Assembly of a fragmented MPD is defined in 5.5. The data model that constitutes a Media Presentation is defined in 5.3. In 5.6, the formats and processing of URLs in the MPD is introduced. Program information is defined in 5.7. Descriptors associated to Representations or collections thereof are provided in 5.8. DASH metric collection description is specified in 5.9.

5.2 Media Presentation Description

5.2.1 General

The Media Presentation Description (MPD) is a document that contains metadata required by a DASH Client to construct appropriate HTTP-URLs to access Segments and to provide the streaming service to the user.

NOTE actual playback of the media streams included in the Representations is not controlled by the MPD information. Playback is controlled by the media engine operating on the media streams contained in the Representations in the usual way.

The format of URLs in the MPD and the process to generate HTTP GET and partial GET requests from URLs provided in the MPD is defined in 5.6.

The MPD is an XML document that is formatted according to the XML schema provided in Annex B. Some context on the schema is provided in 5.2.2.

The extension of the DASH XML schema (as provided in Annex B), in particular the addition of XML attributes or elements in the DASH namespace is reserved to ISO/IEC. Elements and attributes that have been added to the namespace compared to earlier revisions of this standard are documented in 5.2.3.

The MPD shall be authored such that, after XML attributes or elements in the DASH namespace but not in the XML schema documented in Annex B are removed, the result is a valid XML document formatted according to that schema and that conforms to this part of ISO/IEC 23009.

In addition, the MPD shall be authored such that, after XML attributes or elements in the other namespaces than the DASH namespace are removed, the result is a valid XML document formatted according to that schema and that conforms to this part of ISO/IEC 23009.

NOTE 1: Based on the last two paragraphs if DASH clients remove all XML attributes and elements from the MPD in the DASH namespace and in other namespaces that are not in the XML schema documented in Annex B, the MPD results in a valid XML document which complies with this part of ISO/IEC 23009. The DASH client may use such a resulting MPD for presentation of a conforming Media Presentation.

In addition, rules for authoring of MPDs conforming to a specific profile are provided in 8. Certain profiles as defined in 8 of this document may permit ignoring certain elements and attributes. However, this has no effect on the general MPD conformance rules defined in this subsection.

Following XML rules, the MPD document shall contain exactly one **MPD** element as specified in 5.3.

The MIME type of the MPD document is defined in Annex C.

The encoding of the MPD shall be UTF-8 as defined in IETF RFC 3629. All data provided in extension namespaces shall be UTF-8 as defined in IETF RFC 3629. If binary data needs to be added, it shall be included in Base64 as described in IETF RFC 4648 within a UTF-8 encoded element with a proper name space or identifier, such that an XML parser knows how to process or ignore it.

The delivery of the MPD is not in scope of this part of ISO/IEC 23009. However, if the MPD is delivered over HTTP, then the MPD document may be transfer encoded for transport, as described in RFC 2616.

NOTE 1 As an example the GZip algorithm as defined in RFC 1952 [3] may be used for Transfer-encoding.

NOTE 2 MPD encryption is not a normative part of this standard. However, if operating in an insecure environment and required by the content/service provider, elements and attributes of MPD may be encrypted to protect their confidentiality by using the syntax and processing rules specified in the "XML Encryption Syntax and Processing" by W3C [8].

NOTE 3 MPD integrity protection is not a normative part of this standard. However, if operating in an insecure environment and required by the content/service provider, the digital signing and verification procedures specified in the "XML Signature Syntax and Processing" by W3C [9] may be used to protect data origin authenticity and integrity of the MPD.

5.2.2 Schema

The initial part of the XML schema of the MPD is provided below, including namespace and other definitions. Specific types, elements and attributes are introduced in the remainder of this subclause. The complete normative MPD schema is provided in Annex B of this part of ISO/IEC 23009. In case of any inconsistencies the schema in Annex B takes precedence over the XML syntax snippets provided in this clause.

```
<?xml version="1.0"?>
<xs:schema targetNamespace="urn:mpeg:dash:schema:mpd:2011"
  attributeFormDefault="unqualified"
  elementFormDefault="qualified"
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:xlink="http://www.w3.org/1999/xlink"
  xmlns="urn:mpeg:dash:schema:mpd:2011">

  <xs:import namespace="http://www.w3.org/1999/xlink" schemaLocation="xlink.xsd"/>

  <xs:annotation>
    <xs:appinfo>Media Presentation Description</xs:appinfo>
    <xs:documentation xml:lang="en">
      This Schema defines the Media Presentation Description for MPEG-DASH.
    </xs:documentation>
  </xs:annotation>

  <!-- MPD: main element -->
  <xs:element name="MPD" type="MPDtype"/>

  ...
</xs:schema>
```

5.2.3 Elements and Attributes added in Revisions and Amendments

5.2.3.1 Overview

In amendments and revisions of the standard, the schema defined in Annex B may have been extended. In order to track this, section 5.2.3 tracks the addition of elements and attributes.

By following the rules in 5.2.1, a single MPD can be authored for clients that implement different versions of this standard.

5.2.3.2 Elements and Attributes added in this Revision

AC1 This revision adds the following elements and attributes to the schema defined in Annex B compared to the 2012 revision (ISO/IEC 23009-1:2012/Cor 1:2013) of this part of the standard:

- **MPD**@publishTime
- **MPD.EssentialProperty** **AC1**

- AC₁** — **MPD.SupplementalProperty**
 - **Period.AssetIdentifier**
 - **Period.EventStream**
 - **Period.SupplementalProperty**
 - **RepresentationBase.InbandEventStream**
 - **SegmentBase@availabilityTimeOffset**
 - **SegmentBase@availabilityTimeComplete**
 - **BaseURL@availabilityTimeOffset**
 - **BaseURL@availabilityTimeComplete**
 - **Subset@id**
 - **SegmentTimeline.S@n** **AC₁**

5.3 Hierarchical data model

5.3.1 Introduction

5.3.1.1 Overview

A Media Presentation as described in the **MPD** consists of

- A sequence of one or more Periods as described in 5.3.2.
- Each Period contains one or more Adaptation Sets as described in 5.3.3. In case an Adaptation Set contains multiple media content components, then each media content component is described individually as defined in 5.3.4.
- Each Adaptation Set contains one or more Representations as described in 5.3.5.
- Adaptation Sets, Representations and Sub-Representations share common attributes and elements that are described in 5.3.7.
- Each Period may contain one or more Subsets that restrict combination of Adaptation Sets for presentation. Subsets are described in 5.3.8.
- Each Representation consists of one or more Segments described in 6. Segment Information is introduced in 5.3.9. Segments contain media data and/or metadata to access, decode and present the included media content. Representations may also include Sub-Representations as defined in 5.3.6 to describe and extract partial information from a Representation.
- Each Segment consists of one or more Subsegments. Subsegments are described in 6.2.3.2.

The summary of the semantics of the attributes and elements within an **MPD** element are provided in Table 3 of 5.3.1.2. The XML syntax of the **MPD** element is provided in 5.3.1.3.

5.3.1.2 Semantics

Table 3 — Semantics of MPD element

Element or Attribute Name	Use	Description
MPD		The root element that carries the Media Presentation Description for a Media Presentation.
@id	O	<p>specifies an identifier for the Media Presentation. It is recommended to use an identifier that is unique within the scope in which the Media Presentation is published.</p> <p>If not specified, no MPD-internal identifier is provided. However, for example the URL to the MPD may be used as an identifier for the Media Presentation.</p>
@profiles	M	<p>specifies a list of Media Presentation profiles as described in 8.</p> <p>The contents of this attribute shall conform to either the <code>pro-simple</code> or <code>pro-fancy</code> productions of RFC6381, Section 4.5, without the enclosing <code>DQUOTE</code> characters, i.e. including only the <code>unencodedv</code> or <code>encodedv</code> elements respectively. As profile identifier the URI defined for the conforming Media Presentation profiles as described in 8 shall be used.</p>
@type	<p>OD</p> <p>default: static</p>	<p>specifies the type of the Media Presentation. For static Media Presentations (<code>@type="static"</code>) all Segments are available between the <code>@availabilityStartTime</code> and the <code>@availabilityEndTime</code>. For dynamic Media Presentations (<code>@type="dynamic"</code>) Segments typically have different availability times. For details refer to 5.3.9.5.3.</p> <p>In addition the Media Presentation Description may be updated in dynamic Media Presentations, i.e. the <code>@minimumUpdatePeriod</code> may be present.</p> <p>NOTE Static Media Presentations are typically used for On-Demand services, whereas dynamic Media Presentations are used for live services.</p>
@availabilityStartTime	<p>CM</p> <p>Must be present for <code>@type='dynamic'</code></p>	<p>For <code>@type='dynamic'</code> this attribute shall be present. In this case it specifies the anchor for the computation of the earliest availability time (in UTC) for any Segment in the Media Presentation.</p> <p>For <code>@type="static"</code> if present, it specifies the Segment availability start time for all Segments referred to in this MPD. If not present, all Segments described in the MPD shall become available at the time the MPD becomes available.</p>
@publishTime	<p>OD</p> <p>Must be present for <code>@type='dynamic'</code></p>	specifies the wall-clock time when the MPD was generated and published at the origin server. MPDs with a later value of <code>@publishTime</code> shall be an update as defined in 5.4 to MPDs with earlier <code>@publishTime</code> .

Element or Attribute Name	Use	Description
@availabilityEndTime	O	specifies the latest Segment availability end time for any Segment in the Media Presentation. When not present, the value is unknown.
@mediaPresentationDuration	O	<p>specifies the duration of the entire Media Presentation. If the attribute is not present, the duration of the Media Presentation is unknown.</p> <p>This attribute shall be present when neither the attribute MPD@minimumUpdatePeriod nor the Period@duration of the last Period are present.</p>
@minimumUpdatePeriod	O	<p>If this attribute is present, it specifies the smallest period between potential changes to the MPD. This can be useful to control the frequency at which a client checks for updates.</p> <p>[AC2] From a client perspective, after a client fetches an MPD, it specifies the minimum period during which the MPD remains valid. Validity is defined in 5.4. [AC2]</p> <p>If this attribute is not present it indicates that the MPD does not change.</p> <p>If MPD@type is [AC2] not 'dynamic' [AC2], @minimumUpdatePeriod shall not be present.</p> <p>Details on the use of the value of this attribute are specified in 5.4.</p>
@minBufferTime	M	specifies a common duration used in the definition of the Representation data rate (see @bandwidth attribute in 5.3.5.2 [AC2] and 5.3.5.4 [AC2]).
@timeShiftBufferDepth	O	specifies the duration of the smallest time shifting buffer for any Representation in the MPD that is guaranteed to be available for a Media Presentation with type 'dynamic'. When not present, the value is infinite. This value of the attribute is undefined if the type attribute is equal to 'static'.
@suggestedPresentationDelay	O	<p>when @type is 'dynamic', it specifies a fixed delay offset in time from the presentation time of each access unit that is suggested to be used for presentation of each access unit. For more details refer to 7.2.1. When not specified, then no value is provided and the client is expected to choose a suitable value.</p> <p>when @type is 'static' the value of the attribute is undefined and may be ignored.</p>
@maxSegmentDuration	O	specifies the maximum duration of any Segment in any Representation in the Media Presentation, i.e. documented in this MPD and any future update of the MPD. If not present, then the maximum Segment duration shall be the maximum duration of any Segment documented in this MPD.
@maxSubsegmentDuration	O	specifies the maximum duration of any Media Subsegment in any Representation in the Media Presentation. If not present, the same value as for the maximum Segment duration is implied.

Element or Attribute Name	Use	Description
ProgramInformation	0...N	specifies descriptive information about the program. For more details refer to the description in 5.7.
BaseURL	0...N	specifies a Base URL that can be used for reference resolution and alternative URL selection. For more details refer to the description in 5.6.
Location	0...N	specifies a location at which the MPD is available.
Period	1...N	specifies the information of a Period. For more details refer to the description in 5.3.2.
Metrics	0 ... N	specifies the DASH Metrics. For more details see 5.9.
EssentialProperty	0 ... N	specifies information about the containing element that is considered essential by the Media Presentation author for processing the containing element. For details see 5.8.4.8.
SupplementalProperty	0 ... N	specifies supplemental information about the containing element that may be used by the DASH client optimizing the processing. For details see 5.8.4.9.

Legend:

For attributes: M=Mandatory, O=Optional, OD=Optional with Default Value, CM=Conditionally Mandatory.

For elements: <minOccurs>...<maxOccurs> (N=unbounded)

Elements are **bold**; attributes are non-**bold** and preceded with an @**5.3.1.3 XML syntax**

```

<!-- MPD Type -->
<xs:complexType name="MPDtype">
  <xs:sequence>
    <xs:element name="ProgramInformation" type="ProgramInformationType" minOccurs="0"
maxOccurs="unbounded"/>
    <xs:element name="BaseURL" type="BaseURLType" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="Location" type="xs:anyURI" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="Period" type="PeriodType" maxOccurs="unbounded"/>
    <xs:element name="Metrics" type="MetricsType" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="EssentialProperty" type="DescriptorType" minOccurs="0"
maxOccurs="unbounded"/>
    <xs:element name="SupplementalProperty" type="DescriptorType" minOccurs="0"
maxOccurs="unbounded"/>
    <xs:any namespace="##other" processContents="lax" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="id" type="xs:string"/>
  <xs:attribute name="profiles" type="xs:string" use="required"/>
  <xs:attribute name="type" type="PresentationType" default="static"/>
  <xs:attribute name="availabilityStartTime" type="xs:dateTime"/>
  <xs:attribute name="availabilityEndTime" type="xs:dateTime"/>
  <xs:attribute name="publishTime" type="xs:dateTime"/>
  <xs:attribute name="mediaPresentationDuration" type="xs:duration"/>
  <xs:attribute name="minimumUpdatePeriod" type="xs:duration"/>
  <xs:attribute name="minBufferTime" type="xs:duration" use="required"/>
  <xs:attribute name="timeShiftBufferDepth" type="xs:duration"/>
  <xs:attribute name="suggestedPresentationDelay" type="xs:duration"/>
  <xs:attribute name="maxSegmentDuration" type="xs:duration"/>
  <xs:attribute name="maxSubsegmentDuration" type="xs:duration"/>
  <xs:anyAttribute namespace="##other" processContents="lax"/>
</xs:complexType>

<!-- Presentation Type enumeration -->
<xs:simpleType name="PresentationType">
  <xs:restriction base="xs:string">
    <xs:enumeration value="static"/>
    <xs:enumeration value="dynamic"/>
  </xs:restriction>
</xs:simpleType>

```

5.3.2 Period

5.3.2.1 Overview

AC1 A Media Presentation consists of one or more Periods. A Period is defined by a **Period** element in the **MPD** element.

Three types of Periods are defined:

- Regular Period,
- Early Available Period,
- Early Terminated Period.

The type of the Period, as well as the *PeriodStart* time of a regular Period or early terminated Period is determined as follows:

- If the attribute *@start* is present in the **Period**, then the Period is a regular Period or an early terminated Period and the *PeriodStart* is equal to the value of this attribute.
- If the *@start* attribute is absent, but the previous **Period** element contains a *@duration* attribute then this new Period is also a regular Period or an early terminated Period. The start time of the new Period *PeriodStart* is the sum of the start time of the previous Period *PeriodStart* and the value of the attribute *@duration* of the previous Period.
- If (i) *@start* attribute is absent, and (ii) the **Period** element is the first in the MPD, and (iii) the **MPD@type** is 'static', then the *PeriodStart* time shall be set to zero.
- If (i) *@start* attribute is absent, and (ii) the previous **Period** element does not contain a *@duration* attribute or the **Period** element is the first in the MPD, and (iii) the **MPD@type** is 'dynamic', then this Period is an Early Available Period (see below for details).
- If (i) *@duration* attribute is present, and (ii) the next **Period** element contains a *@start* attribute or the *@minimumUpdatePeriod* is present, then this Period is an Early Terminated Period (see below for details).

For any regular Period and early terminated Period the following holds: *PeriodStart* reflects the actual time that should elapse after playing the media of all prior Periods in this Media Presentation relative to the *PeriodStart* time of the first Period in the Media Presentation. The Period extends until the *PeriodStart* of the next Period, or until the end of the Media Presentation in the case of the last Period. For regular Periods, the difference between the *PeriodStart* time of a Period and either the *PeriodStart* time of the following Period, if this is not the last Period, or the value of the **MPD@mediaPresentationDuration** if this is the last one, is the presentation duration in Media Presentation time of the media content represented by the Representations in this Period. For Early Terminated Periods, the value of the **Period@duration** is the presentation duration in Media Presentation time of the media content represented by the Representations in this Period.

Early Available Periods may be used to advertise initialization of other non-media data before the media data itself is available. **Period** elements documenting early available Periods shall not occur before any **Period** element documenting a regular Period. For Early Available Periods, any resources that are announced in such a **Period** element shall be available. The data contained in such a **Period** element does not represent a Period in the Media Presentation. Only when the *PeriodStart* time becomes known through an update of the MPD, such a **Period** element represents a regular Period. However, an update of the MPD may even remove a **Period** element representing an Early Available Period in later updates of the MPD as long as no *PeriodStart* time is associated with the Period. **AC1**

To avoid dereferencing of a remote element entity containing a **Period** element solely to determine the Period timeline, e.g. in case of seeking, **Period@start** or previous Period's **Period@duration** should be present in the MPD.

The semantics of the attributes and elements within a **Period** element are provided in Table 4 of 5.3.2.2. The XML syntax of the **Period** element is provided in 5.3.2.3.

5.3.2.2 Semantics

Table 4 — Semantics of Period element

Element or Attribute Name	Use	Description
Period		specifies the information of a Period.
@xlink:href	O	specifies a reference to a remote element entity that is either empty or contains one or multiple top-level elements of type Period
@xlink:actuate	OD default: onRequest	specifies the processing instructions, which can be either "onLoad" or "onRequest". This attribute shall not be present if the @xlink:href attribute is not present.
@id	O	specifies an identifier for this Period. The identifier shall be unique within the scope of the Media Presentation. If the MPD@type is "dynamic", then this attribute shall be present and shall not change in case the MPD is updated. If not present, no identifier for the Period is provided.
@start	O	if present, specifies the <i>PeriodStart</i> time of the Period. The <i>PeriodStart</i> time is used as an anchor to determine the MPD start time of each Media Segment as well as to determine the presentation time of each access unit in the Media Presentation timeline. If not present, refer to the details in 5.3.2.1.
@duration	O	if present specifies the duration of the Period to determine the <i>PeriodStart</i> time of the next Period. If not present, refer to the details in 5.3.2.1.
@bitstreamSwitching	OD Default: false	When set to 'true', this is equivalent as if the AdaptationSet@bitstreamSwitching for each Adaptation Set contained in this Period is set to 'true'. In this case, the AdaptationSet@bitstreamSwitching attribute shall not be set to 'false' for any Adaptation Set in this Period.
BaseURL	0...N	specifies a base URL that can be used for reference resolution and alternative URL selection. For more details refer to the description in 5.6.
SegmentBase	0...1	specifies default Segment Base information. Information in this element is overridden by information in AdaptationSet.SegmentBase and Representation.SegmentBase , if present. For more details see 5.3.9.
SegmentList	0...1	specifies default Segment List information. Information in this element is overridden by information in AdaptationSet.SegmentList and Representation.SegmentList , if present. For more details see 5.3.9.
SegmentTemplate	0...1	specifies default Segment Template information. Information in this element is overridden by information in AdaptationSet.SegmentTemplate and Representation.SegmentTemplate , if present. For more details see 5.3.9.
AssetIdentifier	0...1	specifies that this Period belongs to a certain asset. For more details see 5.8.5.7.

AC1

Element or Attribute Name	Use	Description
EventStream	0...N	specifies an event stream. For more details see 5.10.2.
AdaptationSet	0...N	specifies an Adaptation Set. At least one Adaptation Set shall be present in each Period unless the value of the @duration attribute of the Period is set to zero. For more details see 5.3.3.
Subset	0...N	specifies a Subset. For more details see 5.3.8.
SupplementalProperty	0...N	specifies supplemental information about the containing element that may be used by the DASH client optimizing the processing. For details see 5.8.4.9..
Legend: For attributes: M=Mandatory, O=Optional, OD=Optional with Default Value, CM=Conditionally Mandatory. For elements: <minOccurs>...<maxOccurs> (N=unbounded) Note that the conditions only holds without using xlink:href. If linking is used, then all attributes are "optional" and <minOccurs=0> Elements are bold ; attributes are non-bold and preceded with an @.		

AC1

5.3.2.3 XML syntax

AC1

```

<!-- Period -->
<xs:complexType name="PeriodType">
  <xs:sequence>
    <xs:element name="BaseURL" type="BaseURLType" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="SegmentBase" type="SegmentBaseType" minOccurs="0"/>
    <xs:element name="SegmentList" type="SegmentListType" minOccurs="0"/>
    <xs:element name="SegmentTemplate" type="SegmentTemplateType" minOccurs="0"/>
    <xs:element name="AssetIdentifier" type="DescriptorType" minOccurs="0"/>
    <xs:element name="EventStream" type="EventStreamType" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="AdaptationSet" type="AdaptationSetType" minOccurs="0"
maxOccurs="unbounded"/>
    <xs:element name="Subset" type="SubsetType" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="SupplementalProperty" type="DescriptorType" minOccurs="0"/>
    <xs:any namespace="##other" processContents="lax" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute ref="xlink:href"/>
  <xs:attribute ref="xlink:actuate" default="onRequest"/>
  <xs:attribute name="id" type="xs:string" />
  <xs:attribute name="start" type="xs:duration"/>
  <xs:attribute name="duration" type="xs:duration"/>
  <xs:attribute name="bitstreamSwitching" type="xs:boolean" default="false"/>
  <xs:anyAttribute namespace="##other" processContents="lax"/>
</xs:complexType>

```

AC1

5.3.3 Adaptation Sets

5.3.3.1 Overview

AC1 Each Period consists of one or more Adaptation Sets. An Adaptation Set is described by an **AdaptationSet** element. **AdaptationSet** elements are contained in a **Period** element.

An Adaptation Set contains alternate Representations, i.e. only one Representation within an Adaptation Set is expected to be presented at a time. All Representations contained in one Adaptation Set represent the same media content components and therefore contain media streams that are considered to be perceptually equivalent. The Adaptation Set and the contained Representations shall be prepared and contain sufficient information such that seamless switching (as defined in 4.5.1) across different Representations in one Adaptation Set is enabled. If an Adaptation Set is expected to be consumed by DASH clients with restrictions in terms of switching, then the Media Presentation author should provide sufficient means to enable seamless switching under these restrictions. **AC1**

Representations are arranged into Adaptation Sets according to the media content component properties of the media content components present in the Representations, namely

- the language as described by the @lang attribute,
- the media component type described by the @contentType attribute,
- the picture aspect ratio as described by the @par attribute,
- the role property as described by the **Role** elements,
- the accessibility property as described by the **Accessibility** elements,
- the viewpoint property as described by the **Viewpoint** elements,
- the rating property as described by the **Rating** elements.

Representations shall appear in the same Adaptation Set if and only if they have identical values for all of these media content component properties for each media content component.

The values for the elements **Role**, **Accessibility**, **Viewpoint** and **Rating** are generally not provided within the scope of this part of ISO/IEC 23009. However, a number of simple schemes are defined in 5.8.5.

If there exist multiple media content components then the properties of each media content component shall be described by a separate **ContentComponent** element as defined in 5.3.4. The **ContentComponent** element shares common elements and attributes with the **AdaptationSet** element. Default values, or values applicable to all media content components, may be provided directly in the **AdaptationSet** element. Attributes present in the **AdaptationSet** shall not be repeated in the **ContentComponent** element.

The **AdaptationSet** element may contain default values for elements and attributes associated to the contained Representations. The list of possible present elements and attributes that are common to **AdaptationSet** and **Representation** (and also **SubRepresentation**) are collected in 5.3.7. Any of the common attributes shall only be present either in the **AdaptationSet** element or in the **Representation** element, but not in both.

The **AdaptationSet** element also supports the description of ranges for the @bandwidth, @width, @height and @frameRate attributes associated to the contained Representations, which provide a summary of all values for all the Representations within this Adaptation Set. The Representations contained within an Adaptation Set shall not contain values outside the ranges documented for that Adaptation Set.

Adaptation Sets may be further arranged into groups using the @group attribute. The semantics of this grouping is that the media content within one Period is represented by:

- 1) either one Representation from group 0, if present,
- 2) or the combination of at most one Representation from each non-zero group.

If the **AdaptationSet**@group attribute is not present then all Representations in this Adaptation Set are assigned to a non-zero group specific to this Adaptation Set.

The semantics of the attributes and elements within an **AdaptationSet** element are provided in Table 5 of 5.3.3.2. The XML syntax of the **AdaptationSet** element is provided in 5.3.3.3.

5.3.3.2 Semantics

Table 5 — Semantics of AdaptationSet element

Element or Attribute Name	Use	Description
AdaptationSet		Adaptation Set description
@xlink:href	O	specifies a reference to a remote element entity that shall contain exactly one element of type AdaptationSet
@xlink:actuate	OD default: 'onRequest'	specifies the processing instructions, which can be either "onLoad" or "onRequest".
@id	O	specifies an unique identifier for this Adaptation Set in the scope of the Period. The attribute shall be unique in the scope of the containing Period. The attribute shall not be present in a remote element entity.

Element or Attribute Name	Use	Description
		If not present, no identifier for the Adaptation Set is specified.
@group	O	specifies an identifier for the group that is unique in the scope of the containing Period. For details refer to 5.3.3.1.
<i>CommonAttributesElements</i>	-	specifies the common attributes and elements (attributes and elements from base type RepresentationBaseType). For details see 5.3.7.
@lang	O	Declares the language code for this Adaptation Set. The syntax and semantics according to IETF RFC 5646 shall be used. If not present, the language code may be defined for each media component or it may be unknown.
@contentType	O	specifies the media content component type for this Adaptation Set. A value of the top-level Content-type 'type' value as defined in RFC4288, Clause 4 shall be taken. If not present, the media content component type may be defined for each media component or it may be unknown.
@par	O	specifies the picture aspect ratio of the video media component type, in the form of a string consisting of two integers separated by ':', e.g., "16:9". When this attribute is present, and the attributes @width and @height for the set of Representations are also present, the picture aspect ratio as specified by this attribute shall be the same as indicated by the values of @width, @height, and @sar, i.e. it shall express the same ratio as $(@width * sar_x) : (@height * sar_y)$, with sar_x the first number in @sar and sar_y the second number. If not present, the picture aspect ratio may be defined for each media component or it may be unknown.
@minBandwidth	O	specifies the minimum @bandwidth value in all Representations in this Adaptation Set. This value has the same units as the @bandwidth attribute. If not present, the value is unknown.
@maxBandwidth	O	specifies the maximum @bandwidth value in all Representations in this Adaptation Set. This value has the same units as the @bandwidth attribute. If not present, the value is unknown.
@minWidth	O	specifies the minimum @width value in all Representations in this Adaptation Set. This value has the same units as the @width attribute.

Element or Attribute Name	Use	Description
		If not present, the value is unknown.
@maxWidth	O	<p>specifies the maximum @width value in all Representations in this Adaptation Set. This value has the same units as the @width attribute.</p> <p>If not present, the value is unknown.</p>
@minHeight	O	<p>specifies the minimum @height value in all Representations in this Adaptation Set. This value has the same units as the @height attribute.</p> <p>If not present, the value is unknown.</p>
@maxHeight	O	<p>specifies the maximum @height value in all Representations in this Adaptation Set. This value has the same units as the @height attribute.</p> <p>If not present, the value is unknown.</p>
@minFrameRate	O	<p>specifies the minimum @frameRate value in all Representations in this Adaptation Set. This value is encoded in the same format as the @frameRate attribute.</p> <p>If not present, the value is unknown.</p>
@maxFrameRate	O	<p>specifies the maximum @frameRate value in all Representations in this Adaptation Set. This value is encoded in the same format as the @frameRate attribute.</p> <p>If not present, the value is unknown.</p>
@segmentAlignment	OD default: false	<p>when not set to 'false', this specifies that for any two Representations, X and Y, within the same Adaptation Set, the m-th Segment of X and the n-th Segment of Y are non-overlapping (as defined in 4.5.3) whenever m is not equal to n.</p> <p>For Adaptation Sets containing Representations with multiple media content components, this attribute value shall be either 'true' or 'false'.</p> <p>For Adaptation Sets containing Representations with a single media content component, when two AdaptationSet elements within a Period share the same integer value for this attribute, then for any two Representations, X and Y, within the union of the two Adaptation Sets, the m-th Segment of X and the n-th Segment of Y are non-overlapping (as defined in 4.5.3) whenever m is not equal to n.</p>
@bitstreamSwitching	O	<p>When this flag is set to 'true', the following applies:</p> <ul style="list-style-type: none"> All Representations in the Adaptation Set shall have the same number M of Media Segments; Let $R_1, R_2, \dots, R_N$ be all the Representations within

Element or Attribute Name	Use	Description
		<p>the Adaptation Set.</p> <ul style="list-style-type: none"> Let <ul style="list-style-type: none"> $S_{i,j}$, for $j > 0$, be the j^{th} Media Segment in the i^{th} Representation (i.e., R_i) if present, let $S_{i,0}$ be the Initialization Segment in the i^{th} Representation, and if present, let B_i be the Bitstream Switching Segment in the i^{th} Representation. The sequence of <ul style="list-style-type: none"> any Initialization Segment, if present, in the Adaptation Set, with, if Bitstream Switching Segments are present, $B_{i(1)}, S_{i(1),1}, B_{i(2)}, S_{i(2),2}, \dots, B_{i(k)}, S_{i(k),k}, \dots, B_{i(M)}, S_{i(M),M}$ else $S_{i(1),1}, S_{i(2),2}, \dots, S_{i(k),k}, \dots, S_{i(M),M},$ <p>wherein any $i(k)$ for all k values in the range of 1 to M, respectively, is an integer value in the range of 1 to N,</p> <p>results in a "conforming Segment sequence" as defined in 4.5.4 with the media format as specified in the @mimeType attribute.</p> <p>More detailed rules may be defined for specific media formats.</p>
@subsegmentAlignment	<p>OD</p> <p>default: false</p>	<p>If the @subsegmentAlignment for an Adaptation Set is set to other than 'false', all following conditions shall be satisfied:</p> <ul style="list-style-type: none"> Each Media Segment shall be indexed (i.e. either it contains a Segment index or there is an Index Segment providing an index for the Media Segment) For any two Representations, X and Y, within the same Adaptation Set, the m-th Subsegment of X and the n-th Subsegment of Y are non-overlapping (as defined in 4.5.3) whenever m is not equal to n. For Adaptation Sets containing Representations with a single media content component, when two AdaptationSet elements within a Period share

Element or Attribute Name	Use	Description
		the same integer value for this attribute, then for any two Representations, X and Y, within the union of the two Adaptation Sets, the <i>m</i> -th Subsegment of X and the <i>n</i> -th Subsegment of Y are non-overlapping (as defined in 4.5.3) whenever <i>m</i> is not equal to <i>n</i> .
@subsegmentStartsWithSAP	OD default: 0	when greater than 0, specifies that each Subsegment with SAP_type greater than 0 starts with a SAP of type less than or equal to the value of @subsegmentStartsWithSAP. A Subsegment starts with SAP when the Subsegment contains a SAP, and for the first SAP, I _{SAU} is the index of the first access unit that follows I _{SAP} , and I _{SAP} is contained in the Subsegment. The semantics of @subsegmentStartsWithSAP equal to 0 are unspecified.
Accessibility	0 ... N	specifies information about accessibility scheme For more details refer to 5.8.1 and 5.8.4.3.
Role	0 ... N	specifies information on role annotation scheme For more details refer to 5.8.1 and 5.8.4.2.
Rating	0 ... N	specifies information on rating scheme. For more details refer to 5.8.1 and 5.8.4.4.
Viewpoint	0 ... N	specifies information on viewpoint annotation scheme. For more details refer to 5.8.1 and 5.8.4.5.
ContentComponent	0...N	specifies the properties of one media content component contained in this Adaptation Set. For more details refer to 5.3.4.
BaseURL	0...N	specifies a base URL that can be used for reference resolution and alternative URL selection. For more details refer to the description in 5.6.
SegmentBase	0...1	specifies default Segment Base information. Information in this element is overridden by information in the Representation.SegmentBase, if present. For more details see 5.3.9.
SegmentList	0...1	specifies default Segment List information. Information in this element is overridden by information in the Representation.SegmentList, if present.

Element or Attribute Name	Use	Description
		For more details see 5.3.9.
SegmentTemplate	0...1	<p>specifies default Segment Template information.</p> <p>Information in this element is overridden by information in the Representation.SegmentTemplate, if present.</p> <p>For more details see 5.3.9.</p>
Representation	0 ... N	<p>specifies a Representation.</p> <p>At least one Representation element shall be present in each Adaptation Set. The actual element may however be part of a remote element entity if xlink is used on the containing AdaptationSet element.</p> <p>For more details refer to 5.3.5.</p>
<p>Legend:</p> <p>For attributes: M=Mandatory, O=Optional, OD=Optional with Default Value, CM=Conditionally Mandatory, F=Fixed. For elements: <minOccurs>...<maxOccurs> (N=unbounded) Note that the conditions only holds without using <code>xlink:href</code>. If linking is used, then all attributes are "optional" and <minOccurs=0></p> <p>Elements are bold; attributes are non-bold and preceded with an @, List of elements and attributes is in <i>italics bold</i> referring to those taken from the Base type that has been extended by this type.</p>		

5.3.3.3 XML syntax

```

<!-- Adaptation Set -->
<xs:complexType name="AdaptationSetType">
  <xs:complexContent>
    <xs:extension base="RepresentationBaseType">
      <xs:sequence>
        <xs:element name="Accessibility" type="DescriptorType" minOccurs="0"
maxOccurs="unbounded"/>
        <xs:element name="Role" type="DescriptorType" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="Rating" type="DescriptorType" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="Viewpoint" type="DescriptorType" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="ContentComponent" type="ContentComponentType" minOccurs="0"
maxOccurs="unbounded"/>
        <xs:element name="BaseURL" type="BaseURLType" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="SegmentBase" type="SegmentBaseType" minOccurs="0"/>
        <xs:element name="SegmentList" type="SegmentListType" minOccurs="0"/>
        <xs:element name="SegmentTemplate" type="SegmentTemplateType" minOccurs="0"/>
        <xs:element name="Representation" type="RepresentationType" minOccurs="0"
maxOccurs="unbounded"/>
      </xs:sequence>
      <xs:attribute ref="xlink:href"/>
      <xs:attribute ref="xlink:actuate" default="onRequest"/>
      <xs:attribute name="id" type="xs:unsignedInt"/>
      <xs:attribute name="group" type="xs:unsignedInt"/>
      <xs:attribute name="lang" type="xs:language"/>
      <xs:attribute name="contentType" type="xs:string"/>
      <xs:attribute name="par" type="RatioType"/>
      <xs:attribute name="minBandwidth" type="xs:unsignedInt"/>
      <xs:attribute name="maxBandwidth" type="xs:unsignedInt"/>
      <xs:attribute name="minWidth" type="xs:unsignedInt"/>
      <xs:attribute name="maxWidth" type="xs:unsignedInt"/>
      <xs:attribute name="minHeight" type="xs:unsignedInt"/>
      <xs:attribute name="maxHeight" type="xs:unsignedInt"/>
      <xs:attribute name="minFrameRate" type="FrameRateType"/>
      <xs:attribute name="maxFrameRate" type="FrameRateType"/>
      <xs:attribute name="segmentAlignment" type="ConditionalUintType" default="false"/>
      <xs:attribute name="subsegmentAlignment" type="ConditionalUintType" default="false"/>
      <xs:attribute name="subsegmentStartsWithSAP" type="SAPType" default="0"/>
      <xs:attribute name="bitstreamSwitching" type="xs:boolean"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>

<!-- Ratio Type for sar and par -->
<xs:simpleType name="RatioType">
  <xs:restriction base="xs:string">
    <xs:pattern value="[0-9]*:[0-9]*"/>
  </xs:restriction>
</xs:simpleType>

<!-- Type for Frame Rate -->
<xs:simpleType name="FrameRateType">
  <xs:restriction base="xs:string">
    <xs:pattern value="[0-9]*[0-9]([/[0-9]*[0-9])?" />
  </xs:restriction>
</xs:simpleType>

<!-- Conditional Unsigned Integer (unsignedInt or boolean) -->
<xs:simpleType name="ConditionalUintType">
  <xs:union memberTypes="xs:unsignedInt xs:boolean"/>
</xs:simpleType>

```

5.3.4 Media Content Component

5.3.4.1 Overview

Each Adaptation Set contains one or more media content components. The properties of each media content component are described by a **ContentComponent** element or may be described directly on the **AdaptationSet** element if only one media content component is present in the Adaptation Set. **ContentComponent** elements are contained in an **AdaptationSet** element.

The semantics of the attributes and elements within a **ContentComponent** element are provided in Table 6 of 5.3.4.2. The XML syntax of the **ContentComponent** element is provided in 5.3.4.3.

5.3.4.2 Semantics

Table 6 — Semantics of ContentComponent element

Element or Attribute Name	Use	Description
ContentComponent		description of a content component
@id	O	specifies an identifier for this media component. The attribute shall be unique in the scope of the containing Adaptation Set. [AC ₂] The value of this attribute should be the media component identifier in the media segment (i.e., the Track Id in ISO BMFF segments and PID in MPEG-2 TS segments) described by this ContentComponent element. [AC ₂]
@lang	O	same semantics as in Table 5 for @lang attribute
@contentType	O	same semantics as in Table 5 for @contentType attribute
@par	O	same semantics as in Table 5 for @par attribute.
Accessibility	0 ... N	same semantics as in Table 5 for Accessibility element
Role	0 ... N	same semantics as in Table 5 for Role element
Rating	0 ... N	same semantics as in Table 5 for Rating element
Viewpoint	0 ... N	same semantics as in Table 5 for Viewpoint element
Legend: For attributes: M=Mandatory, O=Optional, OD=Optional with Default Value, CM=Conditionally Mandatory, F=Fixed. For elements: <minOccurs>...<maxOccurs> (N=unbounded) Elements are bold ; attributes are non-bold and preceded with an @. List of elements and attributes is in italics bold referring to those taken from the Base type that has been extended by this type.		

5.3.4.3 XML syntax

```

<!-- Content Component -->
<xs:complexType name="ContentComponentType">
  <xs:sequence>
    <xs:element name="Accessibility" type="DescriptorType" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="Role" type="DescriptorType" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="Rating" type="DescriptorType" minOccurs="0" maxOccurs="unbounded"/>
    <xs:element name="Viewpoint" type="DescriptorType" minOccurs="0" maxOccurs="unbounded"/>
    <xs:any namespace="##other" processContents="lax" minOccurs="0" maxOccurs="unbounded"/>
  </xs:sequence>
  <xs:attribute name="id" type="xs:unsignedInt"/>
  <xs:attribute name="lang" type="xs:language"/>
  <xs:attribute name="contentType" type="xs:string"/>
  <xs:attribute name="par" type="RatioType"/>
  <xs:anyAttribute namespace="##other" processContents="lax"/>
</xs:complexType>

```

5.3.5 Representation

5.3.5.1 Overview

Representations are described by the **Representation** element. **Representation** elements are contained in an **AdaptationSet** element.

A Representation is one of the alternative choices of the complete set or subset of media content components comprising the media content during the defined Period.

A Representation starts at the start of the Period *PeriodStart* and continues to the end of the Period, i.e. the start of the next Period or the end of the Media Presentation.

Each Representation includes one or more media streams, where each media stream is an encoded version of one media content component.

A Representation consists of one or more Segments.

Each Representation either shall contain an Initialization Segment or each Media Segment in the Representation shall be self-initializing, i.e. the Media Segment itself conforms to the media type as specified in the `@mimeType` attribute for this Representation.

When a Representation is not a dependent Representation, i.e. the `@dependencyId` attribute is absent, then concatenation of the Initialization Segment, if present, and all consecutive Media Segments in one Representation shall represent a conforming Segment sequence as defined in 4.5.4 conforming to the media type as specified in the `@mimeType` attribute for this Representation.

Dependent Representations are described by a **Representation** element that contains a `@dependencyId` attribute. Dependent Representations are regular Representations except that they depend on a set of complementary Representations for decoding and/or presentation. The `@dependencyId` contains the values of the `@id` attribute of all the complementary Representations, i.e. Representations that are necessary to present and/or decode the media content components contained in this dependent Representation.

For any dependent Representation X that depends on complementary Representation Y, the *m*-th Subsegment of X and the *n*-th Subsegment of Y shall be non-overlapping (as defined in 4.5.3) whenever *m* is not equal to *n*. For dependent Representations the concatenation of the Initialization Segment with the sequence of Subsegments of the dependent Representations, each being preceded by the corresponding Subsegment of each of the complementary Representations in order as provided in the `@dependencyId` attribute shall represent a conforming Subsegment sequence as defined in 4.5.4 conforming to the media format as specified in the `@mimeType` attribute for this dependent Representation.

NOTE When decoding of a dependent Representation is started from a SAP in the (Sub)Segment with number *i*, the decoding process does not need to access data from the complementary Representation(s) from any earlier (sub)segments than (sub)Segment with number *i* of the complementary Representation(s).

AC1 **NOTE** In the case a dependent Representation X depends on at least two complementary Representations *Y_i*, that are also dependent Representations depending, directly or indirectly, on the same complementary Representation Z, then the concatenation as defined above results in a sequence conforming to the media format if the Segments of Representation Z are concatenated only the first time encountered following the order in the `@dependencyId` attributes starting from X. If following recursively the dependencies indicated in the `@dependencyId` of Representations, certain Representations may be encountered more than once. In this case the corresponding Segments or Subsegments are expected to only be concatenated once, namely when first encountered. **AC1**

If a Representation is offered in a Media Presentation with `MPD@type='dynamic'`, it is recommended that means to compensate such drift be included. For more details refer to A.8.

The semantics of the attributes and elements within a Representation are provided in Table 7 of 5.3.5.2. The XML syntax of the Representation type is provided in 5.3.5.3.

5.3.5.2 Semantics

Table 7 —Semantics of Representation element

Element or Attribute Name	Use	Description
Representation		This element contains a description of a Representation.
@id	M	<p>specifies an identifier for this Representation. The identifier shall be unique within a Period unless the Representation is functionally identically to another Representation in the same Period.</p> <p>The identifier shall not contain whitespace characters.</p> <p>If used in the template-based URL construction as defined in 5.3.9.4.4, the string shall only contain characters that are permitted within an HTTP-URL according to RFC 3986.</p>
@bandwidth	M	<p>Consider a hypothetical constant bitrate channel of bandwidth with the value of this attribute in bits per second (bps). Then, if the Representation is continuously delivered at this bitrate, starting at any SAP that is indicated either by @startWithSAP or by any Segment Index box, a client can be assured of having enough data for continuous playout providing playout begins after @minBufferTime * @bandwidth bits have been received (i.e. at time @minBufferTime after the first bit is received).</p> <p>For dependent Representations this value specifies the bandwidth according to the above definition for the aggregation of this Representation and all complementary Representations.</p> <p>[AC₂] For details see 5.3.5.4. [AC₂]</p>
@qualityRanking	O	specifies a quality ranking of the Representation relative to other Representations in the same Adaptation Set. Lower values represent higher quality content. If not present then no ranking is defined.
@dependencyId	O	<p>specifies all complementary Representations the Representation depends on in the decoding and/or presentation process as a whitespace-separated list of values of @id attributes.</p> <p>If not present, the Representation can be decoded and presented independently of any other Representation.</p> <p>This attribute shall not be present where there are no dependencies.</p>
@mediaStreamStructureId	O	<p>The attribute may be present for Representations containing video and its semantics are unspecified for any other type of Representations.</p> <p>If present, the attribute @mediaStreamStructureId specifies a whitespace-separated list of media stream structure identifier values. If media streams share the same media stream structure identifier value, the media streams</p>

Element or Attribute Name	Use	Description
		<p>shall have the following characteristics:</p> <ul style="list-style-type: none"> - The media streams have the same number of Stream Access Points of type 1 to 3. - The values of T_{SAP}, T_{DEC}, T_{EPT}, and T_{PTF} of the i-th SAP of type 1 to 3 in one media stream are identical to the values of T_{SAP}, T_{DEC}, T_{EPT}, and T_{PTF}, respectively, of the i-th SAP of type 1 to 3 in the other media streams for any value of i from 1 to the number of SAPs of type 1 to 3 in any of the media streams. - A media stream formed by concatenating the media stream of a first Representation until I_{SAU} (exclusive) of the i-th SAP of type 1 to 3 and the media stream of a second Representation (having the same media stream structure identifier value as for the first Representation) starting from the I_{SAU} (inclusive) of the i-th SAP of type 1 to 3 conforms to the specification in which the media stream format is specified for any value of i from 1 to the number of SAPs of type 1 to 3 in either media stream. Furthermore, the decoded pictures have an acceptable quality regardless of type of the Stream Access Point access unit used. <p>All media stream structure identifier values for one Adaptation Set shall differ from those of another Adaptation Set.</p> <p>If not present, then for this Representation no similarities to other Representations are known.</p> <p>NOTE Indicating multiple media stream structure identifier values for a Representation can be useful in cases where switching between Representations A and B as well as between Representations B and C is allowed at non-IDR intra pictures, but switching between Representations A and C would cause too severe a degradation in the quality of the leading pictures and is hence not allowed. To indicate these permissions and restrictions, Representation A would contain @mediaStreamStructureId equal to "1", Representation B would contain @mediaStreamStructureId equal to "1 2", and Representation C would contain @mediaStreamStructureId equal to "2"</p>
<i>CommonAttributesElements</i>	-	Common Attributes and Elements (attributes and elements from base type RepresentationBaseType), for more details see 5.3.7
BaseURL	0...N	specifies a Base URL that can be used for reference resolution and alternative URL selection. For more details refer to the description in 5.6.

Element or Attribute Name	Use	Description
SubRepresentation	0 ... N	specifies information about a Sub-Representation that is embedded in the containing Representation. For more details see 5.3.6.
SegmentBase	0...1	specifies default Segment Base information. For more details see 5.3.9.
SegmentList	0 ... 1	specifies the Segment List information. For more details see 5.3.9.
SegmentTemplate	0 ... 1	specifies the Segment Template information. For more details see 5.3.9.
Legend: For attributes: M=Mandatory, O=Optional, OD=Optional with Default Value, CM=Conditionally Mandatory. For elements: <minOccurs>...<maxOccurs> (N=unbounded) Elements are bold ; attributes are non-bold and preceded with an @, List of elements and attributes is in <i>italics bold</i> referring to those taken from the Base type that has been extended by this type.		

5.3.5.3 XML syntax

```

<!-- Representation -->
<xs:complexType name="RepresentationType">
  <xs:complexContent>
    <xs:extension base="RepresentationBaseType">
      <xs:sequence>
        <xs:element name="BaseURL" type="BaseURLType" minOccurs="0" maxOccurs="unbounded"/>
        <xs:element name="SubRepresentation" type="SubRepresentationType" minOccurs="0"
maxOccurs="unbounded"/>
        <xs:element name="SegmentBase" type="SegmentBaseType" minOccurs="0"/>
        <xs:element name="SegmentList" type="SegmentListType" minOccurs="0"/>
        <xs:element name="SegmentTemplate" type="SegmentTemplateType" minOccurs="0"/>
      </xs:sequence>
      <xs:attribute name="id" type="StringNoWhitespaceType" use="required"/>
      <xs:attribute name="bandwidth" type="xs:unsignedInt" use="required"/>
      <xs:attribute name="qualityRanking" type="xs:unsignedInt"/>
      <xs:attribute name="dependencyId" type="StringVectorType"/>
      <xs:attribute name="mediaStreamStructureId" type="StringVectorType"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>

<!-- String without white spaces -->
<xs:simpleType name="StringNoWhitespaceType">
  <xs:restriction base="xs:string">
    <xs:pattern value="^[^\r\n\t \p{Z}]*"/>
  </xs:restriction>
</xs:simpleType>

<!-- Whitespace-separated list of strings -->
<xs:simpleType name="StringVectorType">
  <xs:list itemType="xs:string"/>
</xs:simpleType>

```

5.3.5.4 Relation of Bandwidth and Minimum Buffer Time attributes

The MPD contains a pair of values for a bandwidth and buffering description, namely the Minimum Buffer Time (MBT) expressed by the value of `MPD@minBufferTime` and bandwidth (BW) expressed by the value of `Representation@bandwidth`. The following holds:

- the value of the minimum buffer time does not provide any instructions to the client on how long to buffer the media. The value however describes how much buffer a client should have under ideal network conditions. As such, MBT is not describing the burstiness or jitter in the network, it is describing the burstiness or jitter in the content encoding. Together with the BW value, it is a property of the content. Using the "leaky bucket" model, it is the size of the bucket that makes BW true, given the way the content is encoded.
- The minimum buffer time provides information that for each representation, the following shall be true: If the Representation (starting at any segment) is delivered over a constant bitrate channel with bitrate equal to value of the BW attribute then each access unit with presentation time *PT* is available at the client latest at time with a delay of at most *PT* + *MBT*.
- In the absence of any other guidance, the *MBT* should be set to the maximum GOP size (coded video sequence) of the content, which quite often is identical to the maximum segment duration for the live profile or the maximum subsegment duration for the On-Demand profile. The *MBT* may be set to a smaller value than maximum (sub)segment duration, but should not be set to a higher value. 

5.3.6 Sub-Representation

5.3.6.1 Overview

Sub-Representations are embedded in regular Representations and are described by the `SubRepresentation` element. `SubRepresentation` elements are contained in a `Representation` element.

The `SubRepresentation` element describes properties of one or several media content components that are embedded in the Representation. It may for example describe the exact properties of an embedded audio component (e.g., codec, sampling rate, etc.), an embedded sub-title (e.g., codec) or it may describe some embedded lower quality video layer (e.g. some lower frame rate, etc.).

Sub-Representations and Representation share some common attributes and elements.

In case the `@level` attribute is present in the `SubRepresentation` element,

- Sub-Representations provide the ability for accessing a lower quality version of the Representation in which they are contained. In this case, Sub-Representations for example allow extracting the audio track in a multiplexed Representation or may allow for efficient fast-forward or rewind operations if provided with lower frame rate;
- the Initialization Segment and/or the Media Segments and/or the Index Segments shall provide sufficient information such that the data can be easily accessed through HTTP partial GET requests. The details on providing such information shall be defined by the media format in use. For media formats defined in this part of ISO/IEC 23009, the Subsegment Index as defined in 6.3.2.4 shall be used.

If the `@level` attribute is absent, then the `SubRepresentation` element is solely used to provide a more detailed description for media streams that are embedded in the Representation.

The semantics of the attributes and elements within a Sub-Representation are provided in Table 8 of 5.3.6.2. The XML syntax of the Sub-Representation type is provided in 5.3.6.3.

5.3.6.2 Semantics

Table 8 —Semantics of SubRepresentation element

Element or Attribute Name	Use	Description
SubRepresentation		specifies a Sub-Representation.
@level	O	<p>specifies the Sub-Representation level. If @level attribute is present and for media formats used in this Part of ISO/IEC 23009, a Subsegment Index as defined in 6.3.2.4 shall be available for each Media Segment in the containing Representation.</p> <p>If not present, then the SubRepresentation element is solely used to provide a more detailed description for media streams that are embedded in the Representation.</p>
@dependencyLevel	O	<p>specifies the set of Sub-Representations within this Representation that this Sub-Representation depends on in the decoding and/or presentation process as a whitespace-separated list of @level values.</p> <p>If not present, the Sub-Representation can be decoded and presented independently of any other Representation.</p>
@bandwidth	CM shall be present if @level is present	Identical to the @bandwidth definition in Representation, but applied to this Sub-Representation. This attribute shall be present if the @level attribute is present.
@contentComponent	O	<p>if present, specifies the set of all media content components that are contained in this Sub-Representation as a whitespace-separated list of values of ContentComponent@id values.</p> <p>if not present, the Sub-Representation is not assigned to a media content component.</p>
CommonAttributesElements	-	Common Attributes and Elements (attributes and elements from base type RepresentationBaseType). For details see 5.3.7.
<p>Legend: For attributes: M=Mandatory, O=Optional, OD=Optional with Default Value, CM=Conditionally Mandatory. For elements: <minOccurs>...<maxOccurs> (N=unbounded) Elements are bold; attributes are non-bold preceded with an @, List of elements and attributes is in italics bold referring to those taken from the Base type that has been extended by this type.</p>		

5.3.6.3 XML syntax

```
<!-- SubRepresentation -->
<xs:complexType name="SubRepresentationType">
  <xs:complexContent>
    <xs:extension base="RepresentationBaseType">
      <xs:attribute name="level" type="xs:unsignedInt"/>
      <xs:attribute name="dependencyLevel" type="UIntVectorType"/>
      <xs:attribute name="bandwidth" type="xs:unsignedInt"/>
      <xs:attribute name="contentComponent" type="StringVectorType"/>
    </xs:extension>
  </xs:complexContent>
</xs:complexType>

<!-- Whitespace-separated list of unsigned integers -->
<xs:simpleType name="UIntVectorType">
  <xs:list itemType="xs:unsignedInt"/>
</xs:simpleType>
```

5.3.7 Common attributes and elements

5.3.7.1 Overview

The elements **AdaptationSet**, **Representation** and **SubRepresentation** have assigned common attributes and elements. The attributes and elements listed in Table 9 of 5.3.7.2 may be present in all three elements.

The semantics of the common attributes and elements are provided in Table 9 in 5.3.7.2, the syntax is provided in 5.3.7.3.

The 'Use' column in Table 9 shall be interpreted that an attribute marked with 'M' shall be available for a Representation, i.e. it shall either be present in the **Representation** element, or if not, it shall be in the containing **AdaptationSet** element. An attribute marked with 'O' may be absent in both.

5.3.7.2 Semantics

Table 9 — Common Adaptation Set, Representation and Sub-Representation attributes and elements

Element or Attribute Name	Use	Description
Common attributes and elements		
@profiles	O	<p>specifies the profiles which the associated Representation(s) conform to of the list of Media Presentation profiles as described in 8. The value shall be a subset of the respective value in any higher level of the document hierarchy (Representation, Adaptation Set, MPD).</p> <p>If not present, the value is inferred to be the same as in the next higher level of the document hierarchy. For example, if the value is not present for a Representation, then @profiles at the Adaptation Set level is valid for the Representation.</p> <p>The same syntax as defined in 5.3.1.2 shall be used.</p>
@width	O	<p>specifies the horizontal visual presentation size of the video media type on a grid determined by the @sar attribute.</p> <p>In the absence of @sar width and height are specified as if the value of @sar were "1:1"</p>

Element or Attribute Name	Use	Description
		<p>NOTE The visual presentation size of the video is equal to the number of horizontal and vertical samples used for presentation after encoded samples are cropped in response to encoded cropping parameters, "overscan" signaling, or "pan/scan" display parameters, e.g. SEI messages.</p> <p>If not present on any level, the value is unknown.</p>
@height	O	<p>specifies the vertical visual presentation size of the video media type, on a grid determined by the @sar attribute.</p> <p>If not present on any level, the value is unknown.</p>
@sar	O	<p>specifies the sample aspect ratio of the video media component type, in the form of a string consisting of two integers separated by ':', e.g., "10:11". The first number specifies the horizontal size of the encoded video pixels (samples) in arbitrary units. The second number specifies the vertical size of the encoded video pixels (samples) in same units as the horizontal size.</p> <p>If not present on any level, the value is unknown.</p>
@frameRate	O	<p>specifies the output frame rate (or in the case of interlaced, half the output field rate) of the video media type in the Representation. If the frame or field rate is varying, the value is the average frame or half the average field rate field rate over the entire duration of the Representation.</p> <p>The value is coded as a string, either containing two integers separated by a "/", ("F/D"), or a single integer "F". The frame rate is the division F/D, or F, respectively, per second (i.e. the default value of D is "1").</p> <p>If not present on any level, the value is unknown.</p>
@audioSamplingRate	O	<p>Either a single decimal integer value specifying the sampling rate or a whitespace separated pair of decimal integer values specifying the minimum and maximum sampling rate of the audio media component type. The values are in samples per second.</p> <p>If not present on any level, the value is unknown.</p>
@mimeType	M	<p>specifies the MIME type of the concatenation of the Initialization Segment, if present, and all consecutive Media Segments in the Representation.</p>
@segmentProfiles	O	<p>specifies the profiles of Segments that are essential to process the Representation. The detailed semantics depend on the value of the @mimeType attribute.</p> <p>The contents of this attribute shall conform to either the <code>pro-simple</code> or <code>pro-fancy</code> productions of RFC6381, Section 4.5, without the enclosing <code>DQUOTE</code> characters, i.e. including only the <code>unencodedv</code> or <code>encodedv</code> elements respectively. As profile identifier the brand identifier for the Segment as defined in 6 shall be used.</p>

Element or Attribute Name	Use	Description
		If not present on any level, the value may be deducted from the value of the @profiles attribute.
@codecs	O	<p>specifies the codecs present within the Representation. The codec parameters shall also include the profile and level information where applicable.</p> <p>For segment formats defined in this specification this element shall be present and the contents of this attribute shall conform to either the <code>simp-list</code> or <code>fancy-list</code> productions of RFC6381, Section 3.2, without the enclosing <code>DQUOTE</code> characters. The codec identifier for the Representation's media format, mapped into the name space for codecs as specified in RFC6381, Section 3.3, shall be used.</p>
@maximumSAPPeriod	O	<p>when present, specifies the maximum SAP interval in seconds of all contained media streams, where the SAP interval is the maximum time interval between the T_{SAP} of any two successive SAPs of types 1 to 3 inclusive of one media stream in the associated Representations.</p> <p>If not present on any level, the value is unknown.</p>
@startWithSAP	O	<p>when present and greater than 0, specifies that in the associated Representations, each Media Segment starts with a SAP of type less than or equal to the value of this attribute value in each media stream.</p>
		<p>A Media Segment starts with a SAP in a media stream if the stream contains a SAP in that Media Segment, I_{SAU} is the index of the first access unit that follows I_{SAP} and I_{SAP} is contained in the Media Segment.</p> <p>If not present on any level, the value is unknown.</p>
@maxPlayoutRate	O	<p>specifies the maximum playout rate as a multiple of the regular playout rate, which is supported with the same decoder profile and level requirements as the normal playout rate.</p> <p>If not present on any level, the value is 1.</p>
@codingDependency	O	<p>When present and 'true', for all contained media streams, specifies that there is at least one access unit that depends on one or more other access units for decoding. When present and 'false', for any contained media stream, there is no access unit that depends on any other access unit for decoding (e.g. for video all the pictures are intra coded). If not specified on any level, there may or may not be coding dependency between access units.</p>
@scanType	O	<p>specifies the scan type of the source material of the video media component type. The value may be equal to one of "progressive", "interlaced" and "unknown". If not specified on any level, the scan type is "progressive".</p>